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NEW, IMPROVED ELECTRIC BICYCLE

FIELD OF INVENTION:

1. The present invention relates in general to electric powered bicycles, and more particularly to new, improved technology for electric powered bicycles that provides, among other things, steeper and more efficient hill climbing ability, longer range, and a smother ride than the prior art, plus regenerative pedaling.

BACKGROUND OF THE INVENTION:

2. Prior art electric drives for bicycles can be divided into the following four basic types:

1) Friction drive on the tire;

2) Drives through the pedal shaft to the rear wheel;

3) Direct drives to the rear wheel; and

4) Wheel hub motors.

3. The cheapest and simplest type of electric drive for a bicycle is a friction drive on the front or rear tire. This method is so inefficient that it is almost impractical. However this type will probably continue to be built and sold, because they can be easily installed on an existing bicycle as a kit. Patents 6,065,557 to von Keyserling, 5,316,101 to Gannon, and 3,961,678 to Hirano contain examples of this type of drive.

4. State of the art drives through the pedal shaft to the rear wheel are usually heavy, bulky gearboxes with electric motors attached and a pedal shaft protruding on each side. The advantage of this type of drive is that the rear wheel is driven through the normal pedal chain by the pedals and the

motor, or by the pedals alone. Therefore, a normal multi-speed bicycle rear drive can be used to improve hill climbing ability and efficiency. There are a few versions that allow the motor to drive the rear wheel without turning the pedals, but they require additional mechanisms, which increase the cost.

5. A disadvantage of this type of drive is that because the pedal shaft turns at about one third of the speed of the rear wheel in high gear, the rotational speed of the motor must be reduced about three times further when driving through the pedal shaft, than when driving the wheel directly. And then, as the power from the motor is transmitted on through the pedal shaft to the rear wheel it has to be sped up again, to about three times the pedal shaft speed. Both the additional reduction and the subsequent up-speed add to the friction losses and cause a significant loss in overall efficiency.

6. Electric bicycles must carry a large amount of battery weight to have an effective range, and for safety and maneuverability it is very important to keep that weight low and toward the center of the bicycle. Therefore, another disadvantage of driving through the pedal shaft is that the bulky transmission and motor combination around the pedal shaft causes the battery to be relegated to a higher position, away from the center of the bicycle. Patents 6,230,586 to Chang, 6,131,683 to Wada, and 6,015,021 to Sonobe each disclose a different configuration of a drive through the pedal shaft to the rear wheel.

7. Direct drives to the rear wheel take many different forms, but one disadvantage common to all prior art designs is that in addition to the normal pedal chain and sprockets, they customarily require at least two sets of reduction drive units, either chain and sprockets, belt and pulleys, or set of gears from the motor to the rear wheel. This is because the typical lightweight electric motor for this application rotates about ten to twenty times faster than the wheel of a 26 inch electric bicycle when at top speed. A second disadvantage is that in order for the bicycle to coast, or be pedaled efficiently when the motor is not in use an additional ratcheting device (commonly called a "freewheel") is required somewhere in the drive train between the motor and the rear wheel hub. This ratcheting

capability is necessary to avoid the high friction drag caused by the large amount of speed reduction. Still another disadvantage occurs if it is not desirable for the pedals to turn when the motor is driving the bicycle. To free the pedals from turning when the motor is driving the bicycle requires another freewheel somewhere in the drive train between the motor and the pedals. Patents 6,011,366 to Murakami, 5,937,964 to Mayer, 5,433,284 to Chou and, 4,280,581 to Rudwick are some examples of direct drives to the rear wheel.

8. Wheel hub motors look similar to the normal bicycle hubs having flanges with holes for spokes on each side and an axle through the center. However they are much larger in diameter, about six to ten inches, and much heavier, about ten to fifteen pounds. They are made for either front or rear wheel application, but when applied to the front wheel of a bicycle, they create a gyroscopic force that at high speed makes the bicycle hard to steer and dangerous in some conditions. When applied to either end of the bicycle, wheel hub motors increase the polar moment of inertia of the bicycle significantly in both the vertical and horizontal planes. It is well known by those skilled in the art of designing vehicles that this is a highly undesirable characteristic from a handling and safety point of view. When applied to the front of a bicycle with front suspension, the large increase in un-sprung weight renders the suspension practically ineffective, and the same is true at the rear. Patents 6,286,616 to Kutter, 6,093,985 to Chen, and 6,015,021 to Tanaka teach different configurations of wheel hub motors.

9. At constant voltage, as the required torque increases, the speed and the efficiency of a direct current electric motor of the type used on electric bicycles decreases. Therefore, a bicycle with a single gear ratio electric drive is very inefficient when climbing a hill; because it must slow down to develop the required torque to overcome the hill. In moderately hilly terrain, this inefficiency can cut the range of the bicycle in half. The steeper the hill, the less efficient the motor becomes. On a long hill, this

wasted energy usually heats up the motor enough to open the thermal protection switch and turn off the power before the bicycle reaches the top of the hill.

10. Accordingly, the need exists for an electric powered bicycle that incorporates the following important features:

1) A simple, inexpensive multi-speed rear wheel drive that can be driven efficiently by either the pedals or the motor independently, or both in unison, without losing the ability to drive the motor as a generator for charging the batteries by pedaling while coasting downhill or even on flat land.

2) A shifting device that can be used to shift a multi-speed drive to greater speed reductions as the bicycle begins to climb steeper hills. (When the hub shifts to larger reductions, the torque required from the motor to climb the hill is reduced and the efficiency increases.)

3) A motor/drive unit and large battery container that can be fitted to an existing bicycle design or one designed purposely for this use in a position that is low and close to the center of the bicycle.

SUMMARY OF THE INVENTION

11. The first preferred embodiment of this invention provides a simple, efficient way of accomplishing the intent of this invention by using a bicycle rear wheel hub motor as the electric drive unit. Instead of installing the motor in the wheel as the manufacturer intended, the axle of the hub motor is mounted to a bracket that is, in turn, mounted to the frame of the bicycle, just forward of the rear wheel fitted with a multi-speed hub. A sprocket is fixedly mounted to the rotatable outer case of the motor, beside the conventional freewheel, and concentric to the motor axle. A conventional bicycle chain is then operatively connected around the motor sprocket and a sprocket on the multi-speed rear hub to drive the rear wheel. Because the motor turns at the speed of a bicycle wheel the two

sprockets will be about the same size, but the ratio of the number of teeth on each sprocket must be adjusted to obtain the desired top speed of the bicycle, depending on the highest gear ratio of the multi-speed hub used.

12. Another conventional bicycle chain is operatively connected around the conventional large sprocket on the pedal shaft and the sprocket on a conventional freewheel, which is screwed onto the outer case of the motor in the conventional location. This uni-directional drive arrangement provides the rider with the ability to drive the motor, and, in turn, the rear wheel by pedaling the bicycle, but does not turn the pedals, when the bicycle is being driven by the motor alone. Since this type of motor offers almost no resistance to rotation when the power is turned off, this bicycle can be pedaled with almost the same ease as a non-electric bicycle with the same gearing. If the hub motor is one of the newly developed brush-less, direct current, gear-less motors, the motor can be pedaled forward to efficiently recharge the batteries at the command of the rider. This adds only minimally to the effort of pedaling, and is particularly convenient if the bicycle is on at least a slight downhill grade.

13. As is well known by those skilled in the art, the drive function performed by the chain and sprocket arrangement can alternatively be performed by other mechanisms, including gears, shafts, cables, and belts and pulleys.

14. As is well known by those skilled in the art, the conventional freewheel is a uni-directional drive device allowing free rotation of the sprocket when the motor is turning it in the forward direction, but provides a fixed connection when the pedals, through the chain and sprocket, are driving the motor in the same direction. As is also well known by those skilled in the art, the uni-directional drive function performed by the conventional freewheel, in conjunction with a chain and fixed sprocket, can alternatively be performed by using a number of other uni-directional rotating devices, such as a clutch bearing fitted to a sprocket.

15. A second preferred embodiment of this invention is similar to the first preferred embodiment except that a jack-shaft is rotatably mounted, in place of the motor, in the motor mounting brackets. Then a smaller, slightly higher speed motor of the type used in the first preferred embodiment, or of the type that has a fixed case and a rotating shaft, is mounted in the frame beside the jack-shaft. The jack-shaft can then be driven at about the same speed as the large motor it replaced, through a small reduction drive from the smaller, higher speed motor. Pedaling would be accomplished the same way as it is in the first embodiment through a freewheel on the jack-shaft instead of the motor case; and a sprocket fixed to the jack-shaft, instead of the motor case, would be operatively connected to the sprocket on the rear hub through a bicycle chain. This arrangement allows the bicycle to be driven by the motor, through the jack-shaft, to the multi-speed rear hub without turning the pedals.

16. As is well known by those skilled in the art, a jack-shaft is an intermediate shaft, which receives power through chains, belts or gearing and transmits it to other driven rotating members.

17. A third preferred embodiment of this invention is the same as the second preferred embodiment except that the motor is of the small, high speed, either brush or brush-less type. The only other differences are the large reduction drive (between about 10 to 1 and about 20 to 1) between the motor and the jack-shaft, and the presence of the freewheel to drive the jack-shaft. The freewheel is used so that the jack shaft will not have to turn the motor and the large reduction drive when the motor it is turned off and the bicycle is being pedaled. The large reduction drive and the motor would cause a great deal of added frictional drag if it had to be turned when the motor is off and the rider is pedaling the bicycle.

18. It can be seen from the description of the prior art and the above summary of the present invention, how this unique, new concept of a simple, multi-speed drive, that is rotated at a speed which creates the least amount of friction loss for both the pedal power up-speed and the motor power

reduction; and can be fitted into an existing bicycle design, just above the pedal shaft, allowing the battery module to be mounted low on the frame, overcomes the efficiency limitations of the prior art.

BRIEF DESCRIPTION OF THE DRAWINGS:

19. FIG. 1 is an illustration of a first preferred embodiment of the present invention, viewed from the right side.

20. FIG. 2 is a view of the drive train of FIG. 1 with the bracket that holds the motor cut away so that the drive mechanism behind it is visible.

21. FIG. 3 is an illustration of an alternate configuration of the drive train of a first preferred embodiment of the present invention, utilizing a derailleur mechanism on the rear hub instead of a multi-speed hub with internal gears, as illustrated in FIG. 1 and FIG. 2.

22. FIG. 4 is an illustration of the drive train of the second preferred embodiment of the present invention with a slightly higher speed motor driving through a jack-shaft and a speed reduction drive to approximate the speed of the motor in first preferred embodiment.

23. FIG. 5 is an end view of the jack-shaft assembly in FIG. 4.

24. FIG. 6 is an illustration of the drive train of the third preferred embodiment of the present invention with a smaller, higher speed motor driving through a jack-shaft with further speed reduction to again approximate the speed of the motor in first preferred embodiment.

25. FIG. 7 is an end view of the jack-shaft assembly in FIG. 6.

DETAILED DESCRIPTION OF THE INVENTION

26. Referring to FIG. 1, an electric powered bicycle 10 of the present invention preferably includes a frame 12, a front wheel assembly 16, a rear wheel assembly 14, a seat assembly 18, a handle bar and fork assembly 20, a front and rear brake assembly (not shown), a pedal crank assembly 22, a

multi-speed rear hub assembly 24, a pedal sprocket 26, a hub motor assembly 28, a hub motor axle 39, a drive chain 30, a pedal chain 32, a motor support bracket 34, and a battery module 36. The battery module 36 is mounted to the frame 12 in a way that makes it easy to remove in the forward direction and easy to replace in the reverse direction. The battery module 36 fits between sprocket 26 and the left side of pedal crank assembly 22 at a position no lower (closer to the ground) than pedal 22 at its lowest position.

27. Motor 28 was designed as a bicycle hub motor and, therefore, the outer case turns while the axle 39 remains fixed. Bracket 34 is mounted to frame 12 and supports the flattened axle 39 of hub motor 28 in slots 38 on both sides of bracket 34. Motor assembly 28 can be adjusted in slots 38 and tightened into position by axle nuts (not shown) on hub motor axle 39 to adjust the tension on chain 32.

28. FIG. 2 is a view of the drive train in FIG. 1 with the bracket 34 cut away so that the pedal freewheel 40 and the drive sprocket 42 can be seen. Drive sprocket 42 is fixedly and concentrically mounted to the outer case of motor 28, and chain 30 is engaged to sprocket 42 and the conventional sprocket on the multi-speed hub 24, so that when the motor turns, it drives wheel 14. Freewheel 40 is mounted in its conventional position on the case of motor 28 and has the same function in this application as it does when the motor 28 is used as a bicycle rear wheel motor. When the motor 28 is operating, it does not turn the sprocket on the freewheel 40 or the pedal sprocket 26, but when the pedals are also operating and the sprocket on the freewheel 40 is rotated as fast as the motor 28, the pedals can drive the motor, and consequently, the bicycle.

29. FIG. 3 is an illustration of an alternate configuration of the drive train of the first preferred embodiment of the present invention, utilizing a derailleur mechanism on the rear hub instead of a multi-speed hub with internal gears, as illustrated in FIG. 1 and FIG. 2. This configuration utilizes a derailleur mechanism 23 on the rear wheel hub to provide the multi-speed capability. The mechanism

in FIG. 3 is the same as the mechanism in FIG. 1 and FIG. 2, except that chain 31 engages sprocket 42 on motor 28 and one of the sprockets on the multi-sprocket freewheel 25 depending on the position of the conventional bicycle derailleur 23.

30. FIG. 4 is an illustration of the drive train of a second preferred embodiment of the present invention with a slightly higher speed motor driving through a belt and pulleys, chain and sprockets, gears, or the like, to a jack-shaft to provide a speed reduction drive mechanism to approximate the speed of the motor of the first preferred embodiment. In this embodiment of the present invention a rotatable jack-shaft 68 takes the place of motor 28 in FIGS. 1 through 3. Bearings 70 are rotatably mounted to each end of the jack-shaft 68, and the outer races of bearings 70 are fixedly mounted to each side of motor bracket 56, leaving space for multiple sprockets and freewheel 40. In Fig. 4, bracket 56 is cut away so that the pedal freewheel 40 and sprockets 52, 58, and 60 can be seen. Drive sprocket 52 is fixedly and concentrically mounted to the outer case of motor 50, and chain 62 is operably engaged with sprocket 52 and sprocket 58, which is fixedly and concentrically mounted on shaft 68. Sprocket 60 is fixedly and concentrically mounted on shaft 68; and chain 64 is operably engaged with sprocket 60 and the conventional sprocket on the multi-speed hub 24, so that when the motor turns, it drives wheel 14 through chains 62 and 64. Chain 66 is operably engaged with the sprocket on freewheel 40 and the large sprocket 26 on the crank 22. Freewheel 40 is mounted on shaft 68 in the orientation so that when the motor 50 is operating, it does not turn the sprocket on the freewheel 40 nor the pedal sprocket 26. However, when the pedals 22 are also operating and freewheel 40 is rotating as fast as sprocket 58, which is being driven by the motor 50, the pedals 22 can drive the motor 50, the shaft 68, and consequently, the rear wheel of the bicycle.

31. FIG. 5 is an end view of the jack-shaft assembly mounted in bracket 56 of FIG. 4 showing jack-shaft 68, freewheel 40, sprockets 58 and 60, flange bearings 70, machine screws 74, and bracket

56 in there respective positions. Machine screws 74 retain shaft 68 in flange bearings 70 and flange bearings 70 in bracket 56, and sprockets 58 and 60 are fixedly mounted on shaft 68. If shaft 68 is cut from ground and case hardened shafting freewheel 40 could alternately be a sprocket with a drawn cup, needle clutch bearing pressed into it. This could significantly reduce the size of the sprocket compared the smallest bicycle freewheel available; from 16 teeth to about 11 teeth, which would also reduce the size of the large sprocket on the pedal crank by the same percentage for the same ratio. It would also have the combined effect of reducing the cost and the weight.

32. FIG. 6 is an illustration of the drive train of a third preferred embodiment of the present invention which is similar to the second preferred embodiment except with a smaller, much higher speed motor 80 driving jack-shaft 68 through a much larger speed reduction drive, sprocket 82, chain 90, sprocket 88, and a gear set on the motor (not shown), for the same purpose as the small, single reduction drive of FIG. 4. The mechanism illustrated here is the same as in FIG. 4, except that the large sprocket 88, which replaces sprocket 58 in FIG. 4 has a clutch bearing (not shown) pressed into it that is mounted on case hardened jack-shaft 68 in the orientation that allows shaft 68 to turn, when the rider is pedaling without turning sprocket 88, but does not allow the motor 80 to turn sprocket 88 without turning shaft 68. This arrangement thereby allows the motor 80 to drive the rear wheel, but does not allow the pedals to turn the motor 80. There is so much frictional drag when back driving the motor at such high speed through the large speed reduction drive (between about 10 to 1 and about 20 to 1) that the bicycle would be difficult to pedal if the motor had to be turned. But the cost and the weight of a small, high speed motor and reduction drive is much less than the motor of FIG. 2 or FIG. 4.

33. FIG. 7 is an end view of the jack-shaft assembly mounted in bracket 86 of FIG. 6 showing jack-shaft 68, freewheel 40, sprockets 88 and 60, flange bearings 70, machine screws 74, and bracket 56 in there respective positions. The mechanism of FIG. 7 and FIG. 5 are the same

except that there is a clutch bearing (not shown) pressed into sprocket 88 that turns shaft 68 in the forward direction but will not turn sprocket 88 when the shaft is turned forward during pedaling.

34. While the present invention has been illustrated by a description of the preferred embodiments and while these embodiments have been described in considerable detail in order to describe the best mode of practicing the invention, it is not the intention of the applicant to restrict or in any way limit the scope of the appended claims to such detail. For example, if mounted in the correct orientations, freewheel 40 in FIG. 2 could be mounted between the pedal shaft and sprocket 26 with a smaller sprocket fixedly mounted on the motor case, instead of freewheel 40, still providing the same pedaling function intended. Also, the motor brackets and battery box could be formed as part of the structural members of a specially designed bicycle frame, with the present invention in mind.

35. Additional advantages and modifications within the spirit and scope of the invention will readily appear to those skilled in the art. The invention itself should only be defined by the appended claims.